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RECEIVED

9th November, 1998

Federal Communications Commission
Attention: Magalie Roman Salas
Office of Secretary
1919 M Street N.W.
Room 222
Washington D.C. 20554

Ref: NOTICE OF INQUIRY
In the matter of: *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems.*
ET Docket No. 98-153
Adopted: August 20, 1998
Released: September 1, 1998

Dear Sir or Madam:

On behalf of UltraPulse Communications, Inc. ("UCI"), I thank you once again for the opportunity to comment on the proposed revision of Part 15 as it respects UWB transmission technology[1]. UCI is a company which is set up to develop UWB transmission systems for commercial use. I am the principle engineer of UCI and hold a U.S. patent in the area of UWB communications. The attached document in response to the FCC's Notice of Inquiry and prepared by Time Domain Corporation addresses a Part 15 Emissions Measurement Technique. I wish to comment on that response.

In the past the FCC has adopted a universal policy regarding emissions testing for all parts of the regulated spectrum. However, Time Domain requests a special dispensation from FCC measurement rules for what they claim is "their" technology and which they identify as TM-UWB - to distinguish it from other forms of UWB technology. There are two issues which I wish to comment on: (1) whether the identified TM-UWB technology is uniquely Time Domain's; and (2) even if it is uniquely Time Domain's, whether granting a special dispensation is in the spirit of Part 15 and would establish a private monopoly of a public resource.

Regarding the first issue, the books and articles by Harmuth[2] and the patents and articles of Ross[3] and Robbins[4], as well as the extensive Russian work[5], clearly establish priority in the use of emissions which are (pages pp. 2-4):

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[1] UCI's first letter addressing the revision was sent to the FCC on 20th October.

[2] Harmuth, H.F., *Transmission of Information by Orthogonal Functions*, First Edition, Springer, NewYork, 1969;

Harmuth, H.F., *Transmission of Information by Orthogonal Functions*, Second Edition, Springer, New York, 1972;

Harmuth. H.F., Range-Doppler Resolution of Electromagnetic Walsh Waves in Radar. *IEEE Trans. Electromagn. Compat.*, EMC-17, 1975, 106-111;

Harmuth, H.F., Selective Reception of Periodic Electromagmentic Waves with General Time Variation. *IEEE Trans. Electromagn. Compat.*, EMC-19, 1977, 137-144;

Harmuth, H.F., *Sequency Theory*, Academic Press, New York 1977;

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" • Composed of a series of very short pulses.....
• "Carrier-free" signals.
• Noise-like in both the time and frequency domains..."

Therefore it is not true that Time Domain Corporation possesses a "novel time-modulated ultra-wideband (TM-UWB) RF technology". Because the Time Domain approach is not unique or novel, we suggest that the FCC should not even consider offering a special dispensation concerning emissions testing of that technology.

Regarding the second issue: in the interest of fostering the development of UWB communications, the FCC should either (1) propose and pass rules governing the UWB emissions which apply to all companies equally; or (2) in granting a dispensation, make it clear that the dispensation is for a limited time only (perhaps one year) and make it clear that a prior dispensation will have no priority whatsoever when it is time for renewal. It is our view that the first alternative is preferable and the second alternative is likely to engender expensive lawsuits by prior dispensation holders against the FCC and against potential competitors for failure to renew a dispensation, regardless of the language used in the dispensation.

We believe that UWB technologies are superior to traditional AM and FM fixed-frequency modes of transmission. Therefore we believe that the FCC should encourage them. However, we request that this be done through rulemaking, limiting the allowable interference through exacting technical specifications, and not through dispensations. Should the FCC nevertheless determine to grant dispensations to private users, these should be narrow in scope, non-renewable, non-priority for past holders, and explicitly

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Harmuth, H.F., *Nonsinusoidal Waves for Radar and Radio Communication*, Academic, New York, 1981; Harmuth, H.F., *Antennas and Waveguides for Nonsinusoidal Waves*, Academic, New York, 1984.

[3] Bennett, C.L. & Ross, G.F., Time-domain electromagnetics and its application. *Proc. IEEE* 66, 299-318, 1978.

Ross, G.F., Transmission and reception system for generating and receiving base-band duration pulse signals for short base-band pulse communication system. U.S. Patent 3,728,632 dated Apr 17, 1973.

Ross, G.F., Energy amplifying selector gate for base-band signals. U.S. Patent 3,750,025 dated July 31, 1973.

Ross, G.F. & Lamensdorf, D., Balanced radiator system, U.S. Patent 3,659,203 dated Apr, 25, 1972.

Ross, G.F. & Mara, R.M., Coherent processing tunnel diode ultra wideband receiver. U.S. Patent 5,337,054 dated Aug. 9, 1994.

Ross, G.F. & Robbins, K.W., Base-band radiation and reception system. U.S. Patent 3,739,392 dated June 12, 1973.

Ross, G.F. & Robbins, K.W., Narrow range-gate baseband receiver. U.S. Patent 4,695,752 dated Sep 22, 1987.

[4] Robbins, K.W., Short baseband pulse receiver. U.S. Patent 3,662,316 dated May 9, 1972.

Robbins, K.W. & Robbins, G.F., Stable base-band superregenerative selective receiver. U.S. Patent 3,794,996 dated Feb 26, 1974

[5] Astanin, L. Yu. & Kostylev, A.A., *Principles of Superwideband Radar Measurements* Moscow, Radio i Svyaz', 1989.

Glebovich, G.V., Andriyanov, A.V., Vvedenskij, V., Kovalev, I.P., Krylov, V.V. & Ryabinin, A., *Study of Objects Using Picosecond Pulses*, Moscow, Radio i Svyaz', 1984.

Meleshko, E.A., *Nanosecond Electronics in Experimental Physics*, Ehnergoatomizdat Press, Moscow, 1987.

Varganov, M.E., Zinov'ev, Yu.S., Astanin, L.Ya., Kostylev, A.A., Sarychev, V.A., Siezkinskij, S.K., Dmitriev, B.D. *Radar Response of Flight Vehicles*, Moscow, Radio I Svyaz', 1985.

limited to small geographic areas so that other competitors can enter the market. No other approach will prevent the establishment of a few private monopolies.

Thank you for the consideration of these points.

Sincerely yours,

Terence W. Barrett, Ph.D.

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Part 15 Emissions Measurement Technique for TM-UWB Signals

Prepared by: Members of the Technical Staff

Introduction

Time Domain, or Pulson Communications, its wholly owned subsidiary, has been meeting with members of the FCC's staff since 1991 to describe its novel time-modulated ultra-wideband (TM-UWB) RF technology. The basics of this technology, which have been previously presented to various members of the FCC's staff, are described in the attached documents:

- "Time Modulated Ultra-Wideband Technology," Time Domain, April, 1997.
- R.A. Scholtz, "Multiple Access Using Time-Hopping Impulse Modulation," Invited Paper, Proc. MILCOM'93, Boston, MA, October 11 – 14, 1993.

Our most recent discussions have focused on Part 15 mandated techniques for measuring emitted power. These discussions have been necessary because of potential for misinterpretation of FCC Part 15 regulations when dealing with TM-UWB signals. Applying the current regulations, without properly understanding supporting documents, can lead to a misapplication of the rules.

This document discusses:

- How the FCC's measurement requirements can be easily misinterpreted when applied to TM-UWB emissions;
- The proper interpretation of the rules; and
- The rationale for reaching this conclusion.

In summary, we note that:

- It would be technically incorrect and misleading to apply "pulse desensitization" to TM-UWB signals; and
- When correctly interpreted, the rules specify a measurement technique that yields appropriate results.
- This interpretation may not apply to other ultra-wideband techniques.

FCC Measurement Requirements

For frequencies below 1 GHz, the FCC generally specifies a measurement technique using a CISPR quasi-peak detector. Since this measurement technique does not differentiate the type of emissions, i.e., intentional or unintentional, or pulsed or non-pulsed emissions (for pulse repetition frequency above 20 Hz), there are no opportunities for misapplication of the rules to TM-UWB emissions.

Above 1000 MHz, FCC Part 15 regulations can be easily misapplied to TM-UWB waveforms. The potential for misinterpretation results TDSI's description of its waveform as a pulsed waveform and from dependence of the FCC regulations on a chain of supporting documents—a dependence that obscures critical definitions and assumptions. The FCC Part 15 regulations dictate using both average detector and peak detector measurements that are to be conducted in accordance with the measurement standard ANSI C63.4-1992, however:

- CFR 47 Part 15 rules do not wholly agree with, ANSI C63.4-1992. The general section of CFR 47, Part 15 [1] discusses pulse desensitization, implying that pulse desensitization should be applied to measurements of both intentional and unintentional radiators.
- The relevant ANSI C63.4-1992 sections [2], however, apply pulse desensitization to intentional radiators only. The ANSI standard specifies that the measurements of "pulsed" emissions from intentional radiators are to be adjusted for pulse desensitization as specified in the Hewlett Packard Application Note 150-2 [3].
- This HP Applications Note 150-2 applies only to pulsed modulated sinewave carrier signals; more specifically, **a uniform pulse train of sinusoidal waveforms with each pulse containing more than 14 cycles.**[4] If a measured waveform does not meet this specification, then the pulse desensitization equations do not make sense. (See Appendix for a drawing of a pulse modulated sinusoidal carrier.)

TM-UWB Emissions

TM-UWB emissions are necessarily noise-like and non-sinusoidal. Without these attributes, the technology probably would not have sufficient processing gain to allow it to share spectrum with other RF systems. TM-UWB emissions are very definitely not the pulsed sinusoid assumed in the HP application notes. In many respects, this superior spectrum sharing characteristic is the same characteristic that makes measuring the emissions complicated. TM-UWB emissions are:

- Composed of series of very short signals generally similar to the one illustrated in Figure 1. Clearly there are fewer than the 15 cycles required for application of pulse desensitization. This short duration signal spreads the signal over a very, very large bandwidth. (Note: It is possible to generate TM-UWB waveforms with more zero crossing. Such waveforms would have less bandwidth than the waveform shown in Figure 1.)
- "Carrier-free" signals. There is no modulated carrier signal.[5] Each pulse is identical in shape, yet each pulse's time position is either randomly or pseudo-randomly determined and independent in time of any of the other pulses. The random or pseudo-random time modulation makes the signal noise-like, particularly to devices with smaller bandwidths.
- Noise-like in both the time and frequency domains, i.e., at the standard measurement distance the TM-UWB signal is similar to ambient and thermal noise.

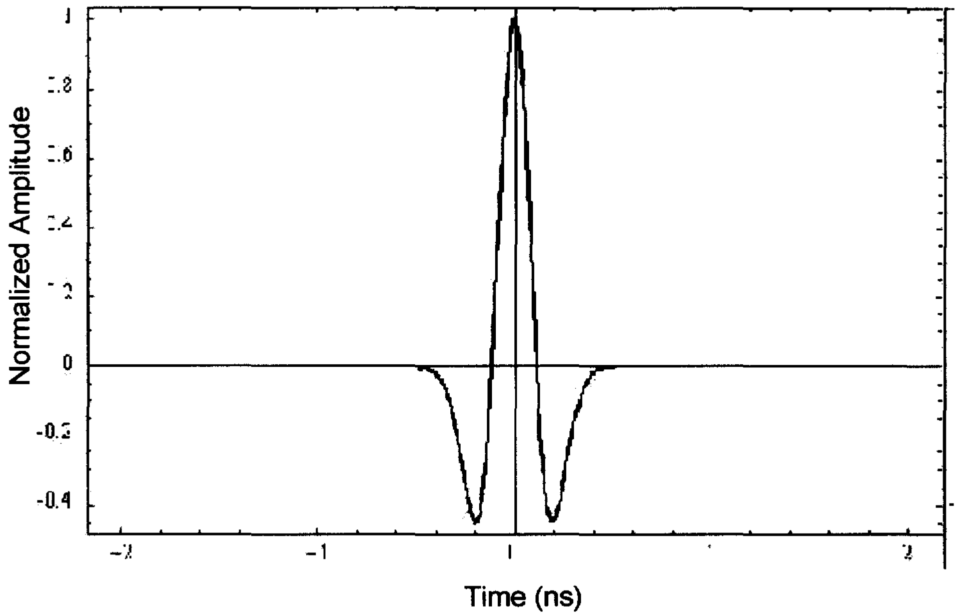

Figure 1. An example of a single TM-UWB waveform.

The noise-like nature of the signal is emphasized by comparing it to the emissions from an unintentional radiator. Such an emission is shown in **Figure 2** from a digital device, except Time Domain's random/pseudo-random time modulation ensures its emissions are decorrelated and even more noise-like.

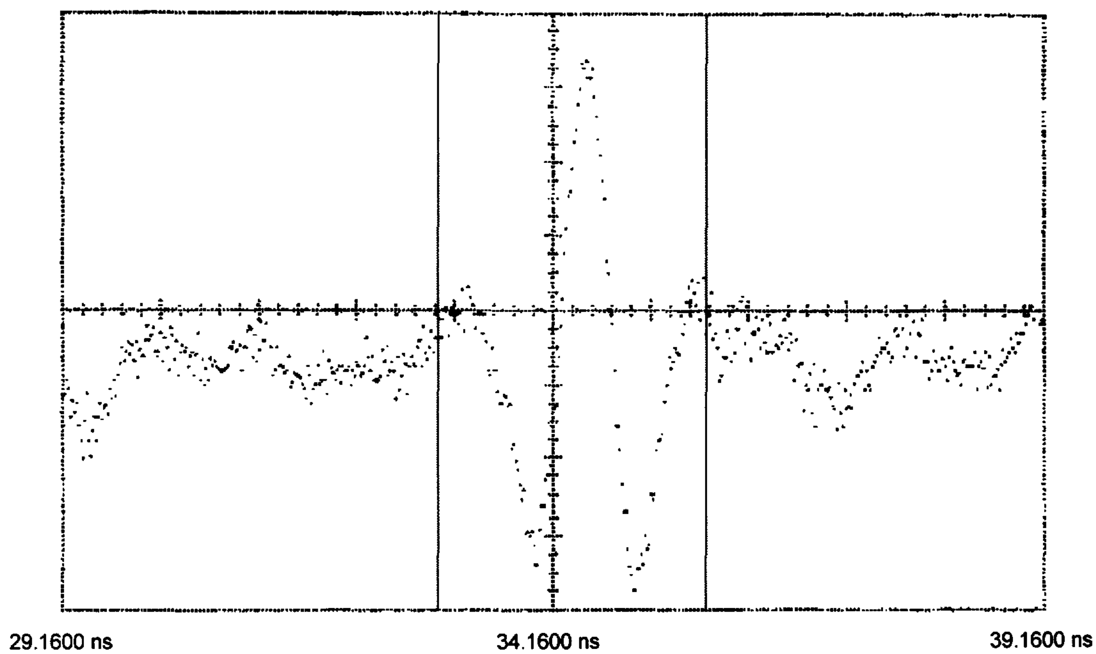

Figure 2. Emission from Pentium personal computer motherboard. Note the ultra-wideband waveform within the vertical lines that strongly resembles the waveform in Figure 1.

The bandwidth of Time Domain's systems also presents a different aspect in terms of the potential harmful interference. The definition of an ultra-wideband signal is that it has greater than 25% relative bandwidth.[6] The bandwidths of Time Domain's systems are generally greater than 60%. It is very improbable that any existing victim receiver would have a bandwidth comparable to a TM-UWB transmission (which in practice generally exceeds 1 GHz). If there were such a system, it would most likely be a spread spectrum system or possibly another TM-UWB system. Such systems depend on processing gain to allow spectrumsharing. Such spread spectrum systems would "despread" the intercepted signals to lower its impact. This despreading enables spread spectrum systems to occupy bandwidths simultaneously with licensed users and other services that transmit several orders of magnitude more power than Time Domain's proposed systems.

The differences between a pulsed sinusoid and Time Domain's TM-UWB emissions are summarized in Table 1.

TM-UWB Emissions	Pulsed Sinusoid
HP App. Note 150-2 is not applicable	HP App. Note 150-2 is applicable
Carrier Free	Pulse modulated sinewave carrier
"W" or many fewer than 14 cycles	Duration > 14 Cycles
Relative Bandwidth > 25%	Relative Bandwidth < 8%
Asymmetric Spectrum	Symmetric Spectrum
Noise Encoded Time Modulation	Uniform Pulse Train
Noise-Like Spectrum	Spectrum Occurs in Harmonics

Table 1. Comparison of pulsed sinusoid to Time Domain's time-modulated ultra-wideband pulses.

The Correct Measurement Procedure

The motivation for measuring the emissions is to estimate the potential of the emission to cause harmful interference. For time-modulated ultra-wideband RF transmissions, the technique that is most faithful to this objective is to use the existing intentional radiator technique for non-pulse modulate sinusoid carrier emissions, i.e., average detector and peak detector measurements with 1 MHz resolution bandwidth without pulse desensitization adjustments. This methodology would also be consistent with measurement technique for similar emissions from unintentional radiators.

It should be noted that this measurement methodology might not apply to other ultra-wideband RF technology systems as they may not conform to the definition of a time-modulated ultra-wideband (TM-UWB) system.

Members of the technical staff of Time Domain were in contact with noted spectrum analyzer expert, Morris Engelson [7], to discuss this particular issue. Mr. Engelson confirmed that Time Domain's signal was indeed noise-like. He also added that the most appropriate way to measure this TM-UWB signal was not to apply pulse desensitization, but rather to do a straight electromagnetic interference measurement, just as Time Domain is stating in this memorandum.

Conclusion

The FCC's Part 15 measurements requirements for RF emissions above 1 GHz include a requirement that pulsed emissions from intentional radiators be adjusted for pulse desensitization. The accurate term for "pulsed emissions" would be "pulse modulated sinusoidal carrier" emissions. Time Domain's TM-UWB signals are not pulse modulated sinusoidal carrier signals. In many respects, TM-UWB emissions are similar to those from digital devices with the exception that great pains are taken to make them extremely noise-like. It is this ultra-wideband noise-like characteristic that allows Time Domain's systems to have such a high processing gain and to allow spectrum reuse. Attempting to apply pulse desensitization as specified in the ANSI standard and the HP application notes would erroneously estimate the potential harmful interference of such a transmission.

Time-modulated ultra-wideband systems should be tested as other intentional radiators, i.e., measured using an average detector and a peak detector with 1 MHz resolution bandwidth without any pulse modulated sinusoidal carrier adjustments. This methodology would also be consistent with the measurement technique applied to similar emissions from unintentional radiators. Moreover, the measurement process of a TM-UWB emission would then be an accurate measure of the interference potential of the emission.

Finally, any other ultra-wideband emission should be evaluated on the basis of its spectral and time domain characteristics. Since other ultra-wideband emissions may not have the same characteristics of TM-UWB emissions, this analysis may not apply to all ultra-wideband emissions.

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1 Code of Federal Regulations 47, Parts 0 to 19, Telecommunications, Washington, D.C., the Office of the Federal Register National Archives and Records Administration, 10/1/94, §15.35

2 ANSI C63.4-1992, American National Standards for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronics Equipment in the range of 9 kHz to 40 GHz, New York, Institute of Electrical and Electronics Engineers, Inc., July 1992, §12.1.4.2 and §13.1.4.2.

3 Spectrum Analyzer Series, Application Note 150-2, Spectrum Analysis .... Pulsed RF, Hewlett Packard, November 1971.

4 Morris Engelson, Modern Spectrum Analyzer Theory and Applications, Dedham, Massachusetts, Artech House, Inc., 1984, p. 149 - 154.

5 Moe Z. Win and R.A. Scholtz, *Comparison of Analog and Digital Impulse Radio for Wireless Multiple Access Communications*, Submitted to IEEE Transactions on Communciations.(A copy of the draft article is attached to this memorandum.)

6 *Introduction to Ultra-Wideband Radar Systems*, Edited by James Taylor, CRC Press, Ann Arbor, 1995 and OSD/DARPA, Ultra-Wideband Radar Review Panel, *Assessment of Ultra-Wideband (UWB) Technology*, DARPA, Arlington, VA, 1990.

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7 Mr. Engelson has over 30 years of experience in the field, he was the Director of Spectrum Analyzer development at Tektronix, adjunct professor at Oregon State University, and author of numerous papers, books, and application notes on spectrum analysis. He is a NARTE Certified EMC Engineer and IEEE Fellow "for contributions to the practice and application of Spectrum Analysis."